# Space Weather Technical Forecast

Issued on Wednesday, 13 December 2023 at 01:04 Local

**This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

**Space Weather Forecast Headline: Chance of isolated M-flares.**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been Low with the peak flare a C9.1 at 12/0338 UTC from AR3514.

There are currently six numbered and one unnumbered sunspot region on the visible disc. AR3513 (Eao/Beta-Gamma) remains the largest region on the disc but continues to decay in its intermediate and trailing spots. AR3514 (Dac/Beta-Delta) continues to evolve and has seen the formation of a minor delta spot within the trailing region. The region exhibits latitudinal bipolarity suggesting magnetic complexity and instability, and is the most active region on the disc. The remaining numbered regions are currently relatively small and simple and are either stable or showing slight signs of decay.

A dimming event was observed around 12/0338 UTC in the vicinity of AR3514 associated with a C9 flare. A CME observed emerging to the west on coronagraph imagery may be attributed to this, initial analysis shows this CME is likely very narrow and as such is currently deemed unlikely to hit earth, however model analysis is yet to be processed so confidence is currently low. Otherwise there was no earth-directed CME's observed in the period.

**Solar Wind / Geomagnetic Activity:** Solar winds as observed by ACE and DSCOVR at L1 were at slow-ambient levels. Wind speeds as measured by ACE were initially around 310 km/s. Winds inclined from 12/1200 UTC, reaching 370-390 km/s and remaining there for the remainder of the period. This slight increase may result from weak influence from a HSS from CH77/+, but more probably is a result of an unexpected glancing blow associated with a filament eruption CME that left the Sun on 08 Dec. Density has remained below average throughout. The Total Interplanetary Magnetic Field (Bt) was initially weak, slow rising to moderate by 12/1000 UTC and peaking at 12.86 nT at 12/1256UTC, before falling back down to weak levels from 12/1700UTC for the rest of the period. The north-south component (Bz) initially varied weakly, before becoming -11nT at 22/1200UTC, then slowly rotated backing to weakly positive by the end of the period. Phi angle was predominantly positive (away from the Sun), but has been negative (towards the Sun) since 12/2000 UTC. Geomagnetic activity was predominately quiet (Kp 0-2), but did become unsettled (Kp 3) between 13/1200-1800.

**Energetic Particles / Solar Radiation:** GOES16 high energy (greater than 10MeV) proton flux remained at background levels. GOES16 high energy (greater than 2MeV) electron flux was predominantly moderate, but was at briefly at high levels 13/1420-1430, peaking at 1120pfu at 12/1425UTC. The 24-hour fluence was below the Active threshold (1e8 integrated pfu). The observation at 13/0000UTC was 1.46e7 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Generally Low solar activity is expected to continue, with a chance of isolated M-flares. These are most likely to emanate from AR3513 or AR3514.

**Solar Wind / Geomagnetic Activity:** There are no Earth-directed CMEs currently expected in the forecast period. However, a dimming event was observed around 12/0338 UTC in the vicinity

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of AR3514. A CME observed emerging to the west on coronagraph imagery may be attributed to this, initial analysis shows this CME is unlikely to hit Earth, although confidence is very low.

Solar winds are most likely to continue at background levels Days 1 (13 Dec) before the onset of a HSS during Day 2 (14 Dec). However, confidence is low in timing and peak wind speeds due to the non-persistent nature of this feature, but slightly elevated winds are expected, possibly reaching elevated levels.

The current Quiet (Kp 0-2) geomagnetic activity is likely to continue until the onset of the HSS from CH79/+, which is anticipated to be on Day 2 (14 Dec). Unsettled to Active conditions are then likely, with a very slight chance of an isolated G1/Minor Geomagnetic Storm interval (Kp 5), but this is considered a low probability at this stage.

**Energetic Particles / Solar Radiation:** GOES16 high energy proton is expected to persist at background levels, with only a very slight chance of rising towards the S1/Minor Radiation Storm level given any significant flares from AR3513 or AR3514. High energy electron flux is expected to be background at first, recovering to moderate levels during Day 1 (13 Dec) and may briefly combine with diurnal peaks Day 1 and 2 (13-14 Dec) to venture into the high threshold, although this is considered only a slight risk. A further suppression is anticipated some point from Day 2 following the anticipated HSS enhancement from CH79/+.

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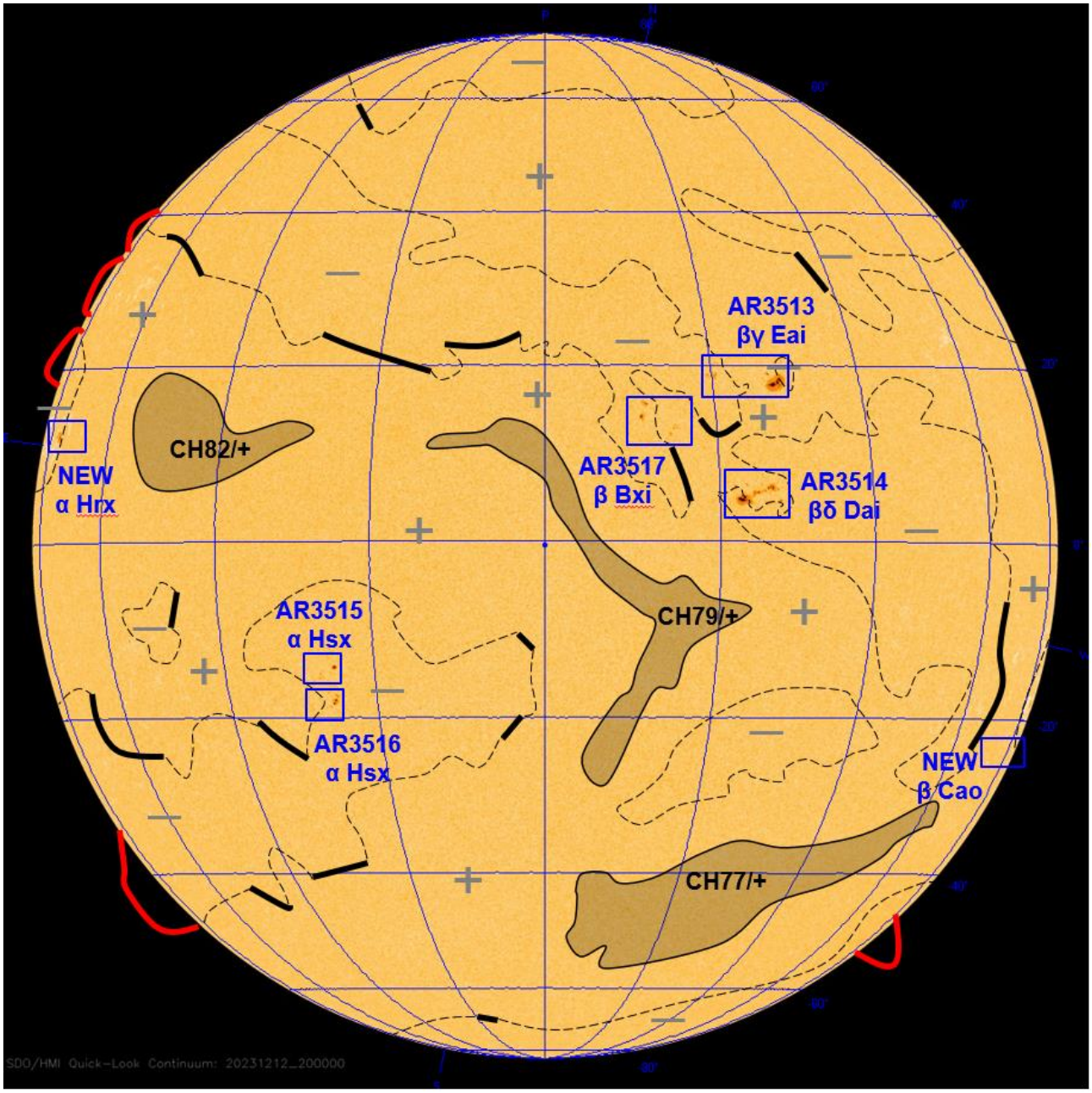
**Figure 1. Solar Analysis Valid 13/2000.**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms:

There are no Earth-directed CMEs currently expected in the forecast period. However, a dimming event was observed around 12/0338 UTC in the vicinity of AR3514 associated with a C9 flare. A CME observed emerging to the west on coronagraph imagery may be attributed to this, initial analysis shows this CME to be very narrow and as such is currently deemed unlikely to hit earth, however model analysis is yet to be processed so confidence is currently very low.

Solar winds are at slow-ambient levels, although increased around 12/1230 UTC to 370-390 km/s where they have since remained. Wind parameters suggest that this slight increase may result from weak influence from a HSS from CH77/+, but more probably is a result of an unexpected glancing blow associated with a filament eruption CME that left the Sun on 08 Dec. Any enhancement to winds expected to decline through Day 1 (13 Dec) back to background levels before the anticipated arrival of a HSS from CH79/+ on Day 2 (14 Dec). Confidence is low in the timing and peak wind speeds due to the non-persistent nature of this coronal hole, but slightly elevated winds are expected, possibly reaching elevated levels Days 2-3 (14-15 Dec).

Despite geomagnetic activity briefly becoming unsettled (Kp 3) on the 12 Dec due to the probable unexpected glancing CME blow, they quickly dropped back to quiet (Kp 0-2) which is expected to continue until the onset of the HSS from CH79/+, anticipated to be on Day 2 (14 Dec). There is a slight chance that the onset of the HSS may produce an isolated G1/Minor Geomagnetic Storm interval (Kp 5), but this is considered a low probability at this stage, with Unsettled to Active conditions more likely.

| Geo-Magnetic Storm Probability (Exceedance) | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| Minor or Moderate | G1 to G2 | No | 5 | 15 | 15 | 5 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

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## Radio Blackouts - X-Ray Flares:

There are currently six numbered and one unnumbered sunspot region on the visible disc. AR3513 (Eao/Beta-Gamma) remains the largest region on the disc but continues to decay in its intermediate and trailing spots. AR3514 (Dac/Beta-Delta) continues to evolve and has seen the formation of a minor delta spot within the trailing region. The region exhibits latitudinal bipolarity suggesting magnetic complexity and instability, and is the most active region on the disc. The remaining numbered regions are currently relatively small and simple and are either stable or showing slight signs of decay.

A new region has developed close to the western limb, but due to its position is difficult to analyse and will soon rotate off the disc. A further region numbered AR3518 (Hsx/alpha) has rotated onto the eastern limb and should become easier to analyse as it rotates further westward.

Seismic analysis of the far-side would suggest that new regions may rotate, or continue to rotate, onto the disc in the coming days, supported by areas of brightness visible beyond the east limb on SDO/AIA-0094. Hence the risk of M flares has been maintained through the next four days.

| X Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 M Class | No | 30 | 30 | 30 | 30 |
| Very Active | R3 to R5 X Class | No | 1 | 1 | 1 | 1 |

**Figure 2: GOES 16 & GOES18 X-Ray trace past 24 hours.**

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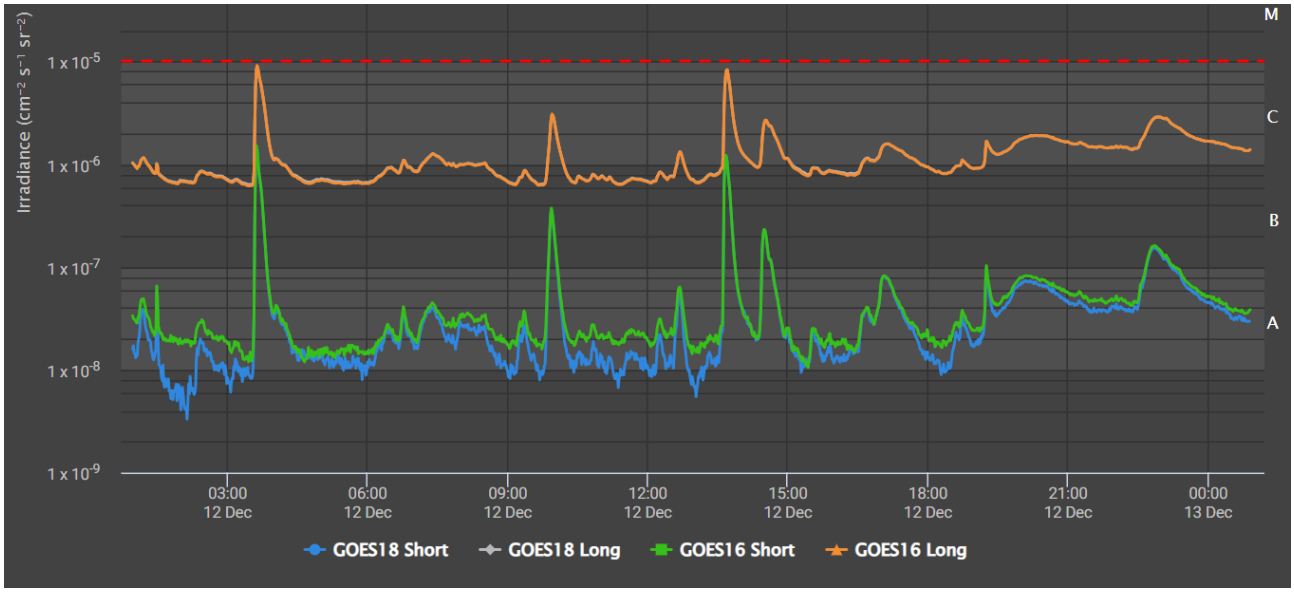


**Solar Radiation Storms - (High Energy Protons):**
The high energy (greater than 10MeV) proton flux observed by GOES16 is currently at background levels. There is a slight chance of this increasing should there be any significant flares, primarily AR3513 and AR3514 which are now transiting across the western hemisphere.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | No | 5 | 5 | 5 | 5 |
| **Very Active** | **≥ S3** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

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## High Energy Electrons Event (≥ 2MeV):

High energy electron flux, as observed by GOES-16, are currently at background levels due to the glancing blow from the CME on the 12th of December or the weak connection with CH77/+, or perhaps a combination of the two. Electrons likely to recover back to moderate levels during Day 1 (13 Dec) and may briefly combine with diurnal peaks Day 1 and 2 (13-14 Dec) to venture into the high threshold, although this is considered only a slight risk. A further suppression is anticipated some point from Day 2 following the anticipated HSS enhancement from CH79/+.

The associated 24 hour fluence is expected to remain below the Active threshold, but may rise closer to the Active threshold by the end of the period, depending on the timing and strength of the next anticipated HSS. The REFM is considered to be giving limited useful guidance at present, with the sharp decline on Day 2 (14 Dec) dependent on the strength of connection with the HSS, which is currently uncertain.

| GEO Electron Environment<br>Probability (Exceedance) | Level ($cm^{-2}$ $sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC)<br>(%) | Day 2 (00-24 UTC)<br>(%) | Day 3 (00-24 UTC)<br>(%) | Day 4 (00-24 UTC)<br>(%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ 2 MeV ≥ $1x10^8$** | No | 5 | 10 | 20 | 20 |
| **Very Active** | **≥ 2 MeV ≥ $1x10^9$** | No | 1 | 1 | 1 | 1 |

**Figure 4: GOES16 Electron Flux trace over past 72-hours**

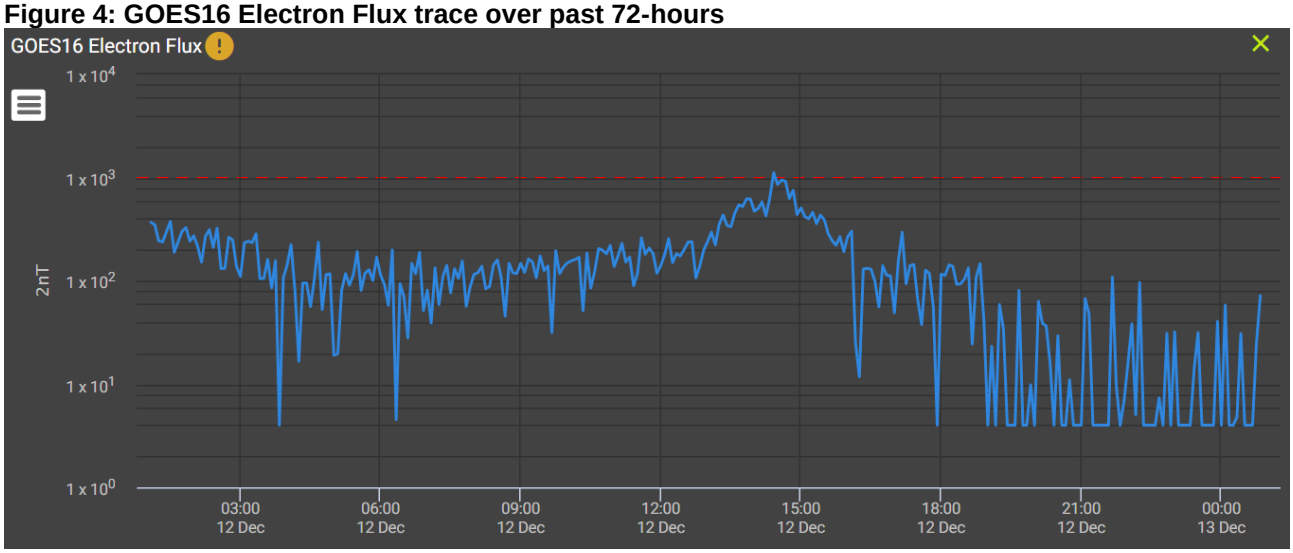


**Figure 5: MOSWOC REFM with uncertain guidance by 14 Dec**

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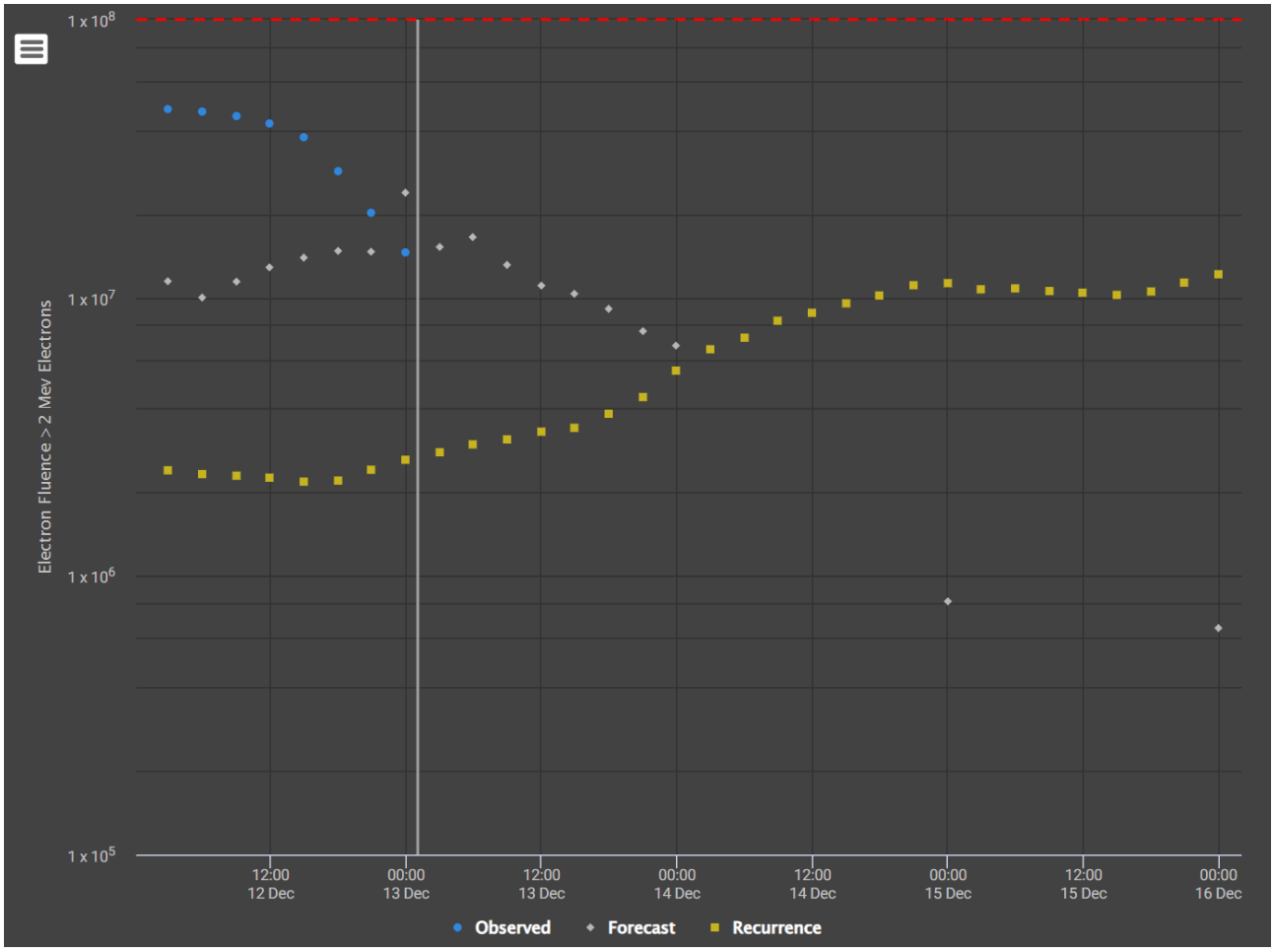


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